

## METHOD AND APPARATUS TO REDUCE VARIATION OF EXCESS FIBER LENGTH IN BUFFER TUBES OF FIBER OPTIC CABLES

### BACKGROUND OF THE INVENTION

#### Field of the Invention

5           The present invention generally relates to the field of optical fibers, in particular to the manufacture of fiber optic buffer tubes having a substantially constant excess fiber length ("EFL") ratio throughout the length of the buffer tube.

#### Discussion of Related Art

10           Optical fibers are very small diameter glass strands which are capable of transmitting an optical signal over great distances, at high speeds, and with relatively low signal loss as compared to standard wire or cable (including wire cable) networks. The use of optical fibers in today's technology has developed into many widespread areas, such as: medicine, aviation, communications, etc. Most applications of optical fibers require the individual fibers to be placed into groupings, such as in fiber optic cables.

15           There are many ways to manufacture and configure fiber optic cables. One of the most common methods of manufacturing a fiber optic cable is by placing a number of fiber optic buffer tubes in a single cable jacket, where each of the buffer tubes is a separate tube having a number of individual optical fibers or optical fiber ribbons. The buffer tubes themselves are hollow tubes generally made from thermoplastic materials.

20           When a cable construction uses a number of buffer tubes, each containing a number of fibers, the quality of the finished cable greatly depends on the quality of the components it uses, in particular, the buffer tubes. The quality of the individual buffer tubes can be affected

by a large number of factors, and the manufacture of the buffer tubes, with the fibers, is one of the most critical of these factors. A common method of manufacturing the buffer tubes is to draw the tubes with the fibers placed inside of the tubes. The buffer tube is then wrapped around a spool and left to cool at room temperature. During this process the tubes are reeled  
5 (in the drawing process) onto a hard or rigid spool (made of any sturdy material for example, wood or steel), and are drawn at a constant draw or take-up tension (on the tube itself) and with a constant angular velocity of the spool.

However, when reeling of the buffer tubes occurs with constant tensile draw on the tubes and constant angular speed of the spool the result is non-uniform distribution of  
10 residual stresses along the length of the buffer tube as it sits on the spool. In some cases, the non-uniform distribution of EFL remains after taking the tube off the spool and subsequently negatively affecting attenuation in the finished cable. The main components, or origins, of the non-uniform, along the tube length, residual deformation stem from (1) stresses along the reeled buffer tube axis (i.e. circumferential stresses) which is a function of the distance from  
15 the reel surface, i.e. current radius and (2) in a transverse direction (i.e. radial stresses) typically varying from zero on the roll surface to a maximum amount on the reel surface. It is noted that this problem not only exists in the fiber optic industry, but also in any other industry where the extended rolling of a product is required. For example, the same problems exist in the manufacture of paper, electrical cable, aluminum sheet, etc. Resulting from these  
20 non-uniform stresses on the spool is the permanent or residual deformation of the rolled material (i.e. buffer tubes) and the creation of residual strains in the tubes and the fibers within the tubes. The creation of residual strain in the fibers is a very serious problem in the

manufacture of fiber optic cables and buffer tubes that causes variation of EFL along the length of the tubes and subsequently attenuation problems.

Excess Fiber Length ("EFL") is an important parameter affecting the quality and performance of a fiber optic cable. EFL is generally defined as a relative difference between the actual individual fiber length (defined as " $L_F$ ") and the length of the buffer tube from which the fiber came (defined as " $L_B$ "), where the % EFL =  $[(L_F - L_B)/L_B] \times 100$ . EFL is important in the proper operation of a fiber optic cable. In general, it is desirable to have a small positive EFL. This means that the length of the fibers is larger than the length of the buffer tube in which the fibers are disposed. This added length allows delayed stretching of the buffer tube under a tensile load during installation or its use without adding any tensile loads on the fibers meaning that, to a certain level of tensile load, the load will be carried by the strength rods or tapes, and not involve the fibers. However, it is important that the EFL should not be too large and have a relatively even distribution throughout the length of the buffer tube. When the EFL distribution throughout the length of a tube is non-uniform it can adversely affect the operation and efficiency of the cable as a whole.

Through testing, it has been discovered that measurements of EFL in buffer tubes wrapped according to prior art methods results in buffer tubes which show an EFL distribution having a skewed parabolic shape. This is depicted in Figure 1, which shows a graphical representation of a typical EFL distribution in a buffer tube wound under the prior art methodology. As shown, the EFL curve 1 is of a typical buffer tube length after manufacture. The left side of the graph indicates the EFL at the early stages of the tube manufacture (i.e. the beginning portion of the tube on the reel). The rapid or steep change in the left part of the EFL curve occurs in the tube length during the initial wraps of the tube on